The Distribution and Abundance of Dryopteris in New Jersey

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The eastern American Wood Ferns are now reasonably well understood as to relationships. There is, however, little quantitative information concerning the local distribution, habitat preference, and abundance of *Dryopteris* hybrids, especially in the northeastern United States. The purpose of this investigation is to document the abundance, distribution, and habitat of the Wood Ferns found in New Jersey.

Although Wood Ferns are found throughout New Jersey, they are particularly common in the more rugged northwestern part of the state (Sussex, Passaic, Warren, and Morris Counties). Hybrids have been known since Dowell (1908) described *Dryopteris clintoniana* × *intermedia* and *D. goldiana* × *marginalis* from New Jersey. In "The Ferns of New Jersey" Chrysler and Edwards (1947) listed 14 hybrids and gave one record for each except *D.* × *boottii;* but no information was given about abundance, distribution, or habitat. Little specific information has been given by recent northeastern fern guides, although *Dryopteris* hybrids are listed and briefly discussed by Wherry (1961). Wagner (1963) discussed the relative abundance of species and hybrids of Wood Ferns in Virginia, and Britton (1965) tabulated their relative abundance in Ontario; no quantitative data were given.

Although hybrids are usually described as being rare, some fern hybrids are relatively common. Wagner (1969), in defense of the inclusion of hybrids in floras, pointed out that several Appalachian *Asplenium* hybrids are more common than the non-hybrid Hart's-tongue (*Phyllitis scolopendrium*), and that *Dryopteris* × *triploidea* and *D.* × *boottii* (both sterile hybrids) are commoner than either *D. celsa* or *D. clintoniana* (both fertile).

Herbarium records for *Dryopteris* hybrids are deceptive. Some of the hybrids are large and conspicuously different, and therefore frequently collected, whereas others are difficult to distinguish and less conspicuous, and so are less often taken. For this reason the abundance of hybrids was measured in two ways in this investigation: (1) the overall abundance, that is the number of stations at which each occurs in New Jersey as determined from herbarium records and field reconnaissance; and (2) the relative abundance as a proportion of the frequency with which a hybrid occurs when the parents are found growing together.

PROCEDURE

Populations of *Dryopteris* where hybrids might occur were located in three ways: (1) examining herbarium labels where reasonably exact data were given, (2) scanning topographic maps for likely habitat areas, and (3) extensive driving and hiking in the area where likely habitats might occur. Once a population had been

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located where two or more species of *Dryopteris* were growing intermixed, a careful search was made to locate all hybrids.

Identifying a plant of *Dryopteris* as a hybrid is usually not difficult; hybrids have abortive spores (Whittier & Wagner, 1971) and frequently sporangia as well, and are generally intermediate in morphology between their parents (see Wagner, 1971). Some hybrids are relatively easy to identify by morphology alone: those involving as parents *D. marginalis* (marginal sori and a dense tuft of tawny scales at the base of the stipes), *D. goldiana* (abrupt taper at the tips of the large blades and very dark, shiny basal scales), *D. intermedia* (glandular blades and indusia and twice pinnatifid pinnae), and *D. spinulosa* (eglandular blades and indusia and twice pinnatifid pinnae). The hybrid between *D. intermedia* and *D. spinulosa* can be distinguished from its similar parents by abortive spores (Tryon & Britton, 1966). Although spore abortion can often be determined with a 10× lens in the field, in this investigation spores were examined with a light microscope at 100×. The hybrids involving *D. celsa*, *D. clintoniana*, and *D. cristata* can be recognized as such, but determining parentage from morphology is often quite difficult. Chromosome counts and pairing behavior are very useful here. Slides were examined from both transplanted and wild plants, following methods given in Montgomery (1975). Voucher specimens for field and cytological studies were deposited in the Chrysler Herbarium of Rutgers University (CHRB), with duplicates in the herbarium of Upsala College (EONJ); duplicates are fronds from the same plant. For ranges and habitats, as well as abundance, material was examined from the following herbaria: AFS, CHRB, EONJ, MICH, NY, PENN, PH, US, and Staten Island Museum (SIM). Habitat information was tabulated from herbarium sheets where sufficient information was given.

RESULTS

Six species and 13 hybrids were found in field studies. The relative frequency of the hybrids was tabulated as a percentage of the number of populations where both parents were present (*Table 1*). The hybrid with the greatest frequency of occurrence when the parents were found together was *D. goldiana* × *marginalis* (100%), followed by *D. intermedia* × *spinulosa* (84%). It should be noted that the first combination of parents was found together only twice, whereas *D. intermedia* and *D. spinulosa* were found together 45 times.

The overall abundance of the species and hybrids, as determined from herbarium records (including the author's material) is given in *Table 2*. In this table a record refers to a distinct locality; duplicates from a locality at the same or different times are eliminated. *Dryopteris marginalis* was the most abundant species, from 176 localities. *D. intermedia* and *D. spinulosa* were nearly as abundant. The most abundant hybrids were *D. intermedia* × *spinulosa* and *D. cristata* × *intermedia*. Both of these, as well as *D. cristata* × *marginalis* were recorded from more stations than the least common species, *D. celsa*, *D. clintoniana*, and *D. goldiana*.

Chromosome counts made to verify taxa are given in *Table 3*. Additional counts from New Jersey were given by Montgomery (1975) and Wagner (1971).

TABLE 1. FREQUENCY OF *Dryopteris* PARENTS AND HYBRIDS IN NEW JERSEY FIELD POPULATIONS.

	× *cristata*		× *goldiana*		× *intermedia*		× *marginalis*		× *spinulosa*	
	n	*f*(%)	*n*	*f*(%)	*n*	*f* (%)	*n*	*f* (%)	*n*	*f* (%)
D. clintoniana	17	58.8	2	50.0	15	40.0	12	25.0	15	26.7
D. cristata			2	50.0	31	58.1	18	55.6	35	17.1
D. goldiana					1	0.0	2	100.0	1	0.0
D. intermedia							27	3.7	45	84.4
D. marginalis									20	5.0

n = number of populations with both parents present.
f = percent of populations (n) where the hybrid was found.

TABLE 2. NUMBER OF LOCALITIES OF *Dryopteris* HYBRIDS IN NEW JERSEY FROM HERBARIUM RECORDS.

	Number of localities for species	*Number of localities for hybrids* × *clintoniana*	× *cristata*	× *goldiana*	× *intermedia*	× *marginalis*	× *spinulosa*
D. celsa	2	0	4	3	2	3	1
D. clintoniana	24		13	6	10	4	5
D. cristata	108			2	45	29	11
D. goldiana	19				1	11	0
D. intermedia	138					2	46
D. marginalis	176						2
D. spinulosa	139						

TABLE 3. CHROMOSOME COUNTS IN NEW JERSEY *Dryopteris*.

I	II	*Source of Material*[1]
	D. cristata	
0	81±1	25466c, Macopin, Passaic Co.
0	82	25473y, Green Pond, Passaic Co.
0	81±1	8250p, Wawayanda, Sussex Co.
	D. goldiana	
0	41	8155b, Netcong, Morris Co.
	D. intermedia	
0	41	25466f, Macopin, Passaic Co.
0	41	11423d, Wallpack, Sussex Co.
	D. cristata × *intermedia* (*D.* × *boottii*)	
123	0	25466b, Macopin, Passaic Co.
122±2	0-1	25466d, Macopin, Passaic Co.
123	0	10528g, Macopin, Passaic Co.
	D. cristata × *marginalis* (*D.* × *slossonae*)	
121±3	0	8250j, Wawayanda, Sussex Co.
123±2	0	10528m, Macopin, Passaic Co.
	D. cristata × *spinulosa* (*D.* × *uliginosa*)	
76	43	7870e, Swartswood, Sussex Co.
	D. intermedia × *spinulosa* (*D.* × *triploidea*)	
40±1	40±2	66010c, Greendell, Sussex Co.

[1] Collected by the author; voucher at CHRB.

DISCUSSION

In general hybrids were found with both parents nearby, usually in sight. Occasionally, however, a hybrid plant was found with only one parent very close by. *Dryopteris* × *triploidea* was found six times with only *D. spinulosa* present; *D.* × *boottii* was found once with *D. cristata* about 0.25 mile away and no *D. intermedia* in the vicinity, and one other time with only *D. cristata* present. Wagner (1971) referred to this phenomenon as "hybridization by remote control," and it presumably happens when a spore from the missing parent is blown into the vicinity of the gametophyte of the other parent so that cross-fertilization can occur. Extinction of one species or the other, or both, at a locality after hybrid formation is another possible mechanism; the hybrid can persist and even spread slowly by rhizome growth. These conditions are unusual, however, and so parent species are usually found in the vicinity of the hybrids.

The abundance of the hybrids would be expected to be related to the abundance of the parental taxa. The quantitative information presented here indicates that this is true in some cases; thus, hybrids involving *D. goldiana* are rare in New Jersey. *Dryopteris intermedia* × *spinulosa* (*D.* × *triploidea*) and *D. cristata* × *intermedia* (*D.* × *boottii*) were common, and the parent species were very common. These were also the only taxa involved in "remote control" hybridization.

Hybrids were also more common if the parents had similar habitat preferences. *Dryopteris clintoniana* × *cristata* was found relatively frequently, both in herbarium records (*Table 2*), although often identified as one or the other parent, and in relative abundance in field studies (*Table 1*). Both parents occupied similar swampy habitats. On the other hand, *D. clintoniana* × *marginalis* was relatively uncommon, and these parents occupied rather different habitats. The most spectacular hybrid populations occurred where a wooded ridge occupied by *D. intermedia* and *D. marginalis* sloped into a wooded swamp occupied by *D. clintoniana*, *D. cristata*, and *D. spinulosa*. In such locations the edge of the swamp may be virtually lined with hybrids! At Big Spring, where *D. goldiana* also occurred, six of 15 possible hybrids were found and the number of hybrid plants was unusually great. In two other areas, Wawayanda and Macopin, five species were present and six of ten possible hybrids were found.

Certain hybrids were inexplicably rare. The most notable case was *D. intermedia* × *marginalis*. The parental species were abundant and occupied similar habitats, and so large intermixed populations were encountered frequently. This hybrid is also relatively easily seen if the population is searched carefully. The same general situation applies to *D. cristata* × *spinulosa* in New Jersey. No explanation is known for the lack of hybridization between these species. Experimental studies with the gametophytes may be helpful.

The relative abundance of hybrids found in New Jersey agrees in general with that found in Virginia by Wagner (1963) and in Ontario by Britton (1965). Both reported *D. intermedia* × *spinulosa* as the commonest hybrid combination, as in the present study. Both stated that *D. intermedia* × *marginalis* and *D. marginalis* × *spinulosa* were rare, as documented here. Britton listed *D. cristata* × *mar-*

ginalis as "rare to very rare" in Ontario; in New Jersey it was recorded from 29 stations (third highest) and found 55.6% of the time when the parents were found growing together. *Dryopteris clintoniana* × *intermedia* was also more frequent in New Jersey than in Ontario.

The distribution, habitat preference, and abundance of each *Dryopteris* species and hybrid in New Jersey are summarized below.

Dryopteris celsa (W. Palmer) Small. Very rare, perhaps extinct. Known from four localities in Bergen County (two by hybrids only); all from swamps that have been destroyed by urbanization.

Dryopteris clintoniana (D. C. Eaton) Dowell. Uncommon. In low woods or wooded swamps; several locations in Sussex County, and a few each in Passaic, Warren, Morris, and Essex Counties.

Dryopteris cristata (L.) Gray. Common. Usually in wooded swamps, growing on old stumps, logs, and hummocks; occasionally in wet meadows or damp woods; recorded from all counties except Hudson and Cumberland, but more common in the northern part of the state.

Dryopteris goldiana (Hook.) Gray. Uncommon. In rich woods or ravines, especially on limestone in New Jersey; several records (mostly old) for Sussex and Warren Counties, and one or two each in Bergen, Morris, Essex, and Hunterdon.

Dryopteris intermedia (Muhl.) Gray. Abundant. Rocky, wooded slopes, especially north- or east-facing, sometimes in wet woods or swamps especially in the southern half of the state; known from all 21 counties.

Dryopteris marginalis (L.) Gray. Abundant. Rocky woods, often drier than *D. intermedia*, and only rarely in swamps; recorded from all counties except Cape May.

Dryopteris spinulosa (O. F. Muell.) Watt. Abundant. In woods, nearly always in moist areas (springs, etc.), or in wooded swamps as *D. cristata*. Recorded from all counties except Union.

Dryopteris celsa hybrids. Five hybrids involving *D. celsa* are recorded from New Jersey: *D. celsa* × *cristata*, *D. celsa* × *goldiana*, *D. celsa* × *intermedia* (*D.* × *separabilis* (Palmer) Small), *D. celsa* × *marginalis* (*D.* × *leedsii* Wherry), *D. celsa* × *spinulosa*; all from Bergen County (Montgomery, 1975).

Dryopteris clintoniana × *cristata*. Uncommon. In swamps, as the parents, but only a few plants; recorded from Sussex, Passaic, Warren, and Morris Counties.

Dryopteris clintoniana × *goldiana*. Uncommon. Edges of swamps with *D. goldiana* above and *D. clintoniana* below; recorded from Sussex, Passaic, Warren, and Essex Counties.

Dryopteris clintoniana × *intermedia* (*D.* × *dowellii* (Farw.) Wherry). Uncommon; edges of swamps or wet woods; type from Macopin, Passaic County, plus several other records in Sussex and Morris Counties.

Dryopteris clintoniana × *marginalis*. Rare. In swamps; three localities in Sussex County, one in Warren County.

Dryopteris clintoniana × *spinulosa* (*D.* × *benedictii* Wherry). Rare. In swamps; five records in Sussex, Passaic, and Morris Counties.

Dryopteris cristata × *goldiana*. Doubtfully present. One sterile collection from Lodi, Bergen County, which could be a *D. celsa* hybrid, and a possible plant from Morris County.

Dryopteris cristata × *intermedia* (*D.* × *boottii* (Tuckerm.) Underw.). Common. Most commonly in swamps or wet woods, but also on wooded slopes, or even on rock walls; occasionally several plants, but more commonly only a few; most of the northern counties, plus Gloucester and Cape May.

Dryopteris cristata × *marginalis* (*D.* × *slossonae* Wherry). Common. Edges of swamps, nearly always on hummocks or stumps; recorded from all northern counties, plus Mercer, Middlesex, and Monmouth in central New Jersey.

Dryopteris cristata × *spinulosa* (*D.* × *uliginosa* Druce). Uncommon. In swamps, rarely more than one or two plants; four localities in Sussex, and one or two each in Passaic, Bergen, Morris, Middlesex, Monmouth, and Burlington Counties.

Dryopteris goldiana × *intermedia*. Rare. One record in Bergen County from an area now destroyed.

Dryopteris goldiana × *marginalis* (*D.* × *neowherryi* Wagner). Uncommon. At borders of swamps or in damp rich woods; several records in Sussex County, plus two each in Bergen and Morris Counties, and one in Hunterdon County.

Dryopteris goldiana × *spinulosa*. Unknown in the state.

Dryopteris intermedia × *marginalis*. Rare. Only two records: in 1914 from Sussex County, and by the author in 1973 in Union County; the latter with the parents on a steep, northwest-facing slope in hemlock woods.

Dryopteris intermedia × *spinulosa* (*D.* × *triploidea* Wherry). Common. In woods, especially open areas such as pine plantations, or edges of swamps, banks of streams, etc.; the commonest hybrid, frequent with the parents and sometimes outnumbering either or both; recorded from nine counties, mostly in the northern part of the state.

D. marginalis × *spinulosa* (*D.* × *pittsfordensis* Slosson). Rare. Only two records, one from a swamp in Middlesex County, the other, possibly from cultivated plants, in Monmouth County.

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